Emerging Lighting Technologies

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US Department of Energy

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Table of Contents

Mission Statements

Office of Energy Efficiency and Renewable Energy

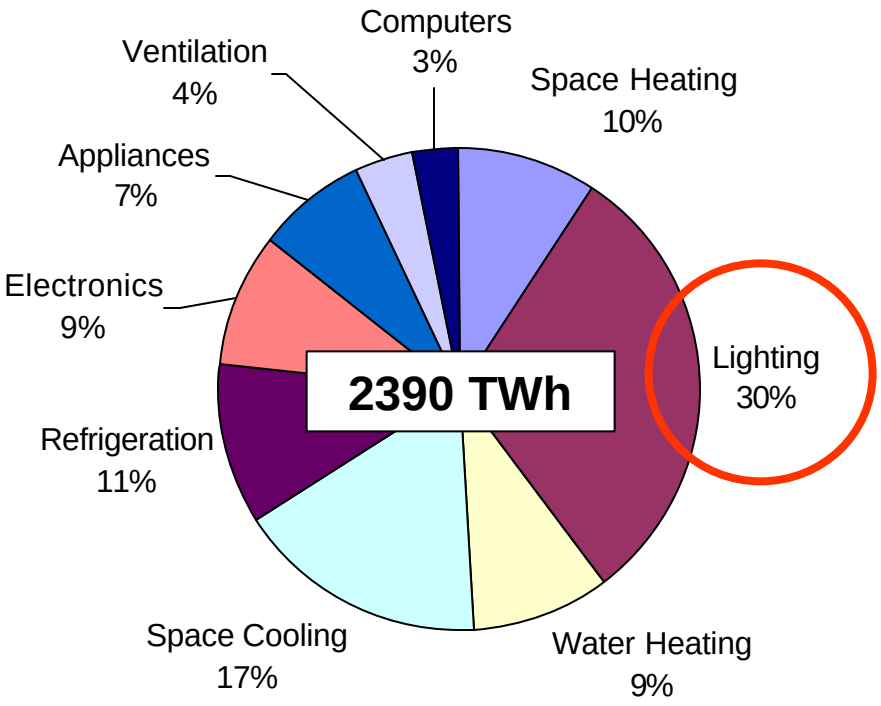
The EERE mission is to strengthen America's energy security, environmental quality, and economic vitality in public-private partnerships that: enhance energy efficiency and productivity; bring clean, reliable and affordable energy technologies to the marketplace; and make a difference in the everyday lives of Americans by enhancing their energy choices and their quality of life.

Lighting Research and Development Program

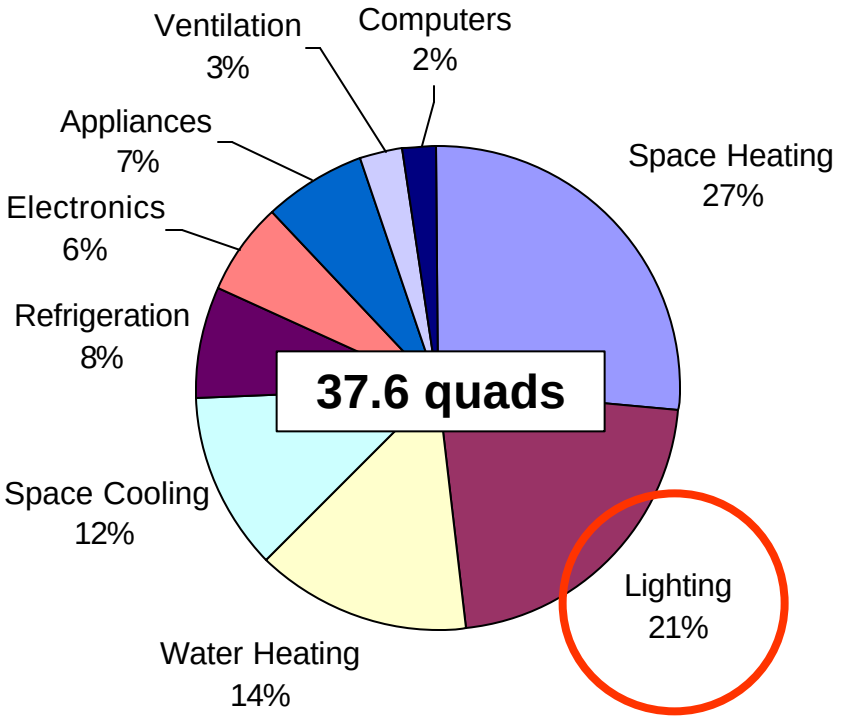
To increase end-use efficiency in buildings by aggressively researching new and evolving lighting technologies, in close collaboration with partners, to develop viable methodologies that have the technical potential to conserve 50% of electric lighting consumption by 2025.

U.S. Buildings Energy End-Use Breakdown, 2001

Site Electricity Consumption



Total Primary Energy (all fuels)



Source: Building Technology Program Core Databook, August 2003. http://buildingsdatabook.eren.doe.gov/frame.asp?p=tableview.asp&TableID=509&t=xls

Table of Contents

IC-Based Controls for Energy-Efficient Lighting

- IC-based ballast platform
- Applicable across fluorescent and HID lamps
- Optimum lamp control, dimming, lower cost, reduced size
- GE Global Research, BT Competitive
- Completed

Selective Thermal Emitters for Incandescent Lighting

- Development of selective "super emitter" based tungsten lamps
- Improve incandescent lamp efficacy
- Decrease infrared emissions
- Foster-Miller, SBIR Competitive
- Completed

Novel Nanophosphors for High Efficiency Fluorescent Lamps

- Advanced phosphors to improve efficiency of mercury discharge in fluorescent lamps
- Increase fluorescent lamp efficiency by 30%
- GE Global Research, BT Competitive
- Research in progress

Table of Contents

Examples of SSL Applications Today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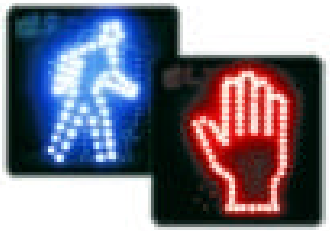


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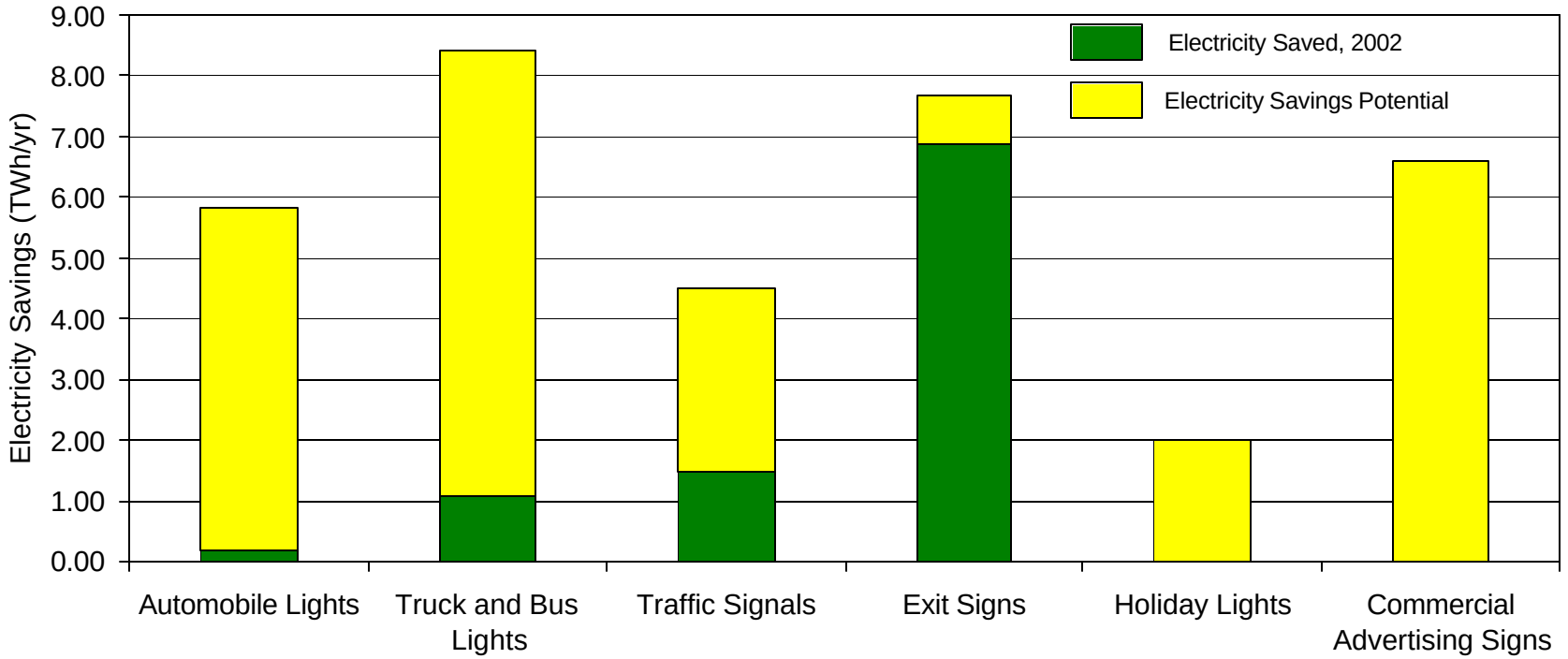
Current and Potential Electricity Savings from LEDs in Niche Applications



Source: Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications, Navigant Consulting, November 2003; www.netl.doe.gov/ssl/.

Solid State Lighting Today

- LEDs are cost-effective in colored-light applications
  - Exit signs, traffic signals, advertising signage, airport taxiway lights
  - 4 states (CA, CT, MD, NJ) mandate efficiency and performance levels for exit signs and traffic signals that are best met with LEDs
  - Legislation pending in ~10 other states
- LEDs are starting to compete in white-light applications
  - Airplane reading lights, directional / task lighting
- High-brightness LEDs represented ~$3.7 billion in 2004
  - Top applications: commercial electric signs (58%), automotive (13%)
- OLEDs focus on display applications and not general illumination

Table of Contents

Efficiency and Cost of White-Light Sources

Source efficacy (2005)

- Incandescent (75W) ~13 lm/W
- Fluorescent (T8) ~83 lm/W
- HID (Metal Halide) ~100 lm/W
- SSL (White LED) ~50 lm/W

Normalized retail lamp price (2005)

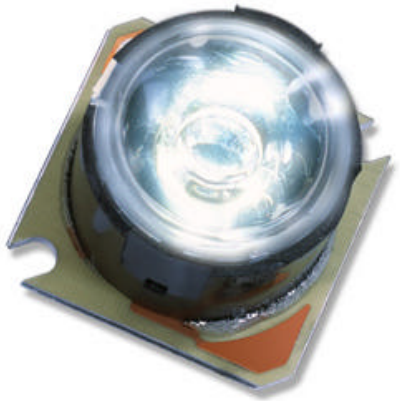
- Incandescent (75W) ~0.60 $/klm
- Fluorescent (T8) ~0.73 $/klm
- HID (Metal Halide) ~1.27 $/klm
- SSL (White LED) ~150.00 $/klm

*manufacturer data

Research is is improving SSL efficacy while decreasing price

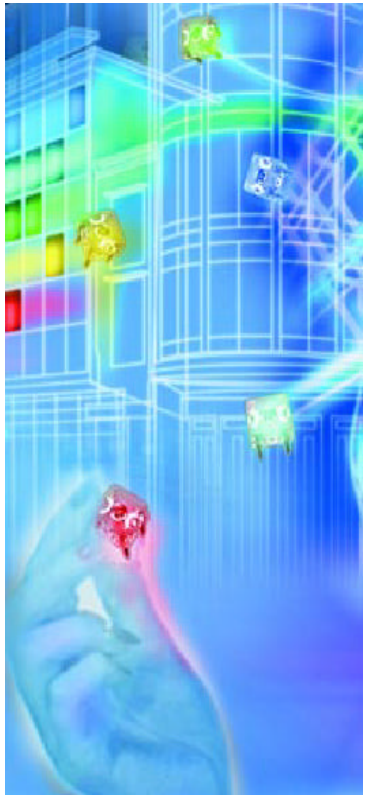
White LEDs Advancing Quickly

- Cree recently announced 60 lumen white
  - Produced the most efficacious white-light LED laboratory device at 74 lumens per watt in 2003
- Lumileds to introduce 65 lumen white products mid-2005
- On par with some fluorescent lighting systems and more than four times more efficient than incandescent sources



White-Light SSL Challenges

- **Lifetime – lumen maintenance; heat management**
- **Efficacy – improving rapidly**
- **Color Quality – high CCTs**
- **Luminous Flux**
- **Cost**
- **Need testing/reporting standards**
- **Ready or Not**

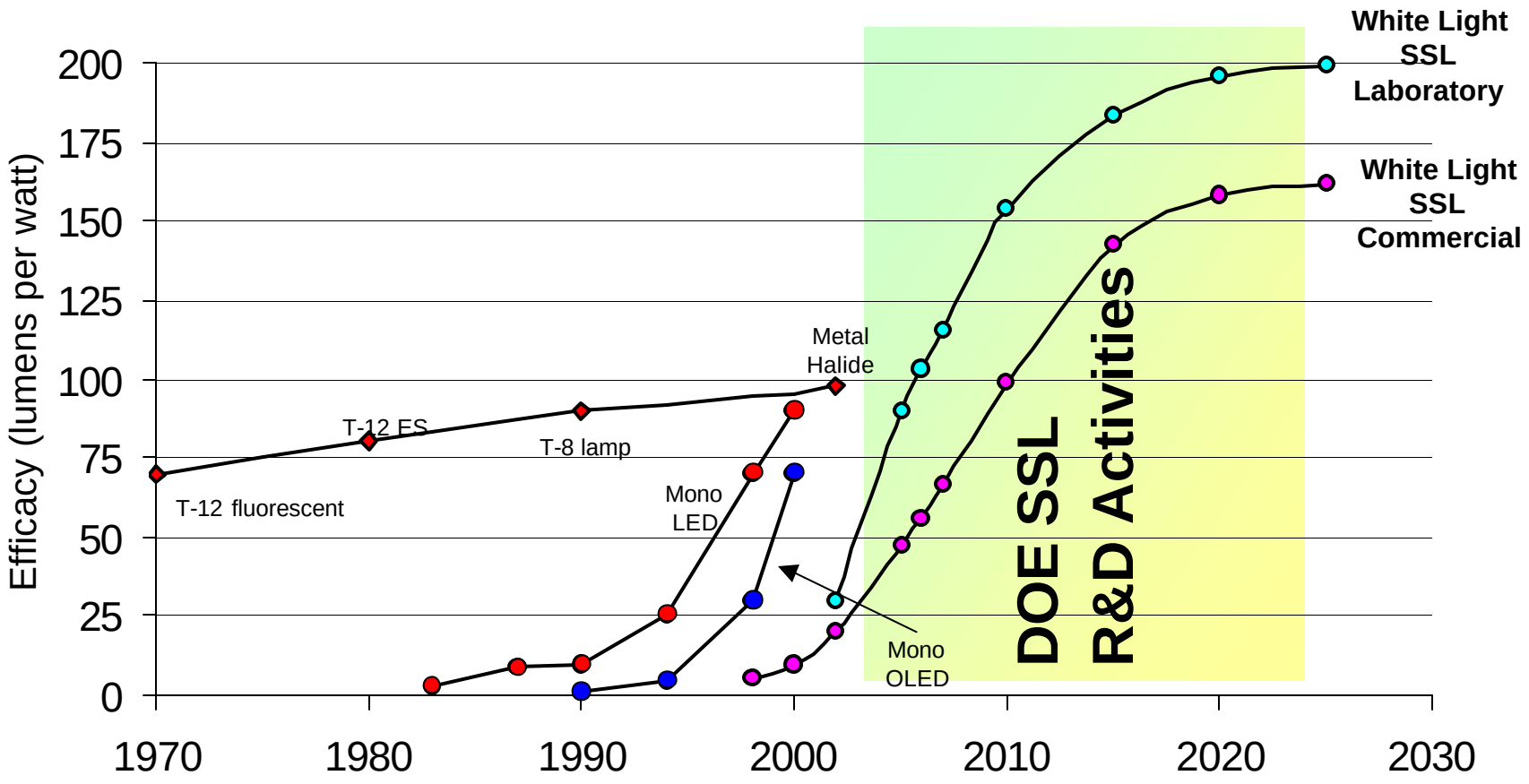


DOE Solid State Lighting R&D Program

- About 42 "research" projects underway
- Key task areas:
  - Inorganic Materials Research
  - Advanced Inorganic Device Architecture and Conversion Materials (chip level)
  - Inorganic Technology Integration (first level package)
  - Manufacturing Equipment and Tools for Low Cost, High Yield Inorganic LED Processing
  - Electro-Active Organic Materials Research
  - Advanced Organic Device Architectures
  - OLED Module Integration
  - Manufacturing Equipment and Tools for OLED Lighting

Table of Contents

Accelerated R&D for White Light SSL



SSL Laboratory and Commercial Curves, revised September 2004

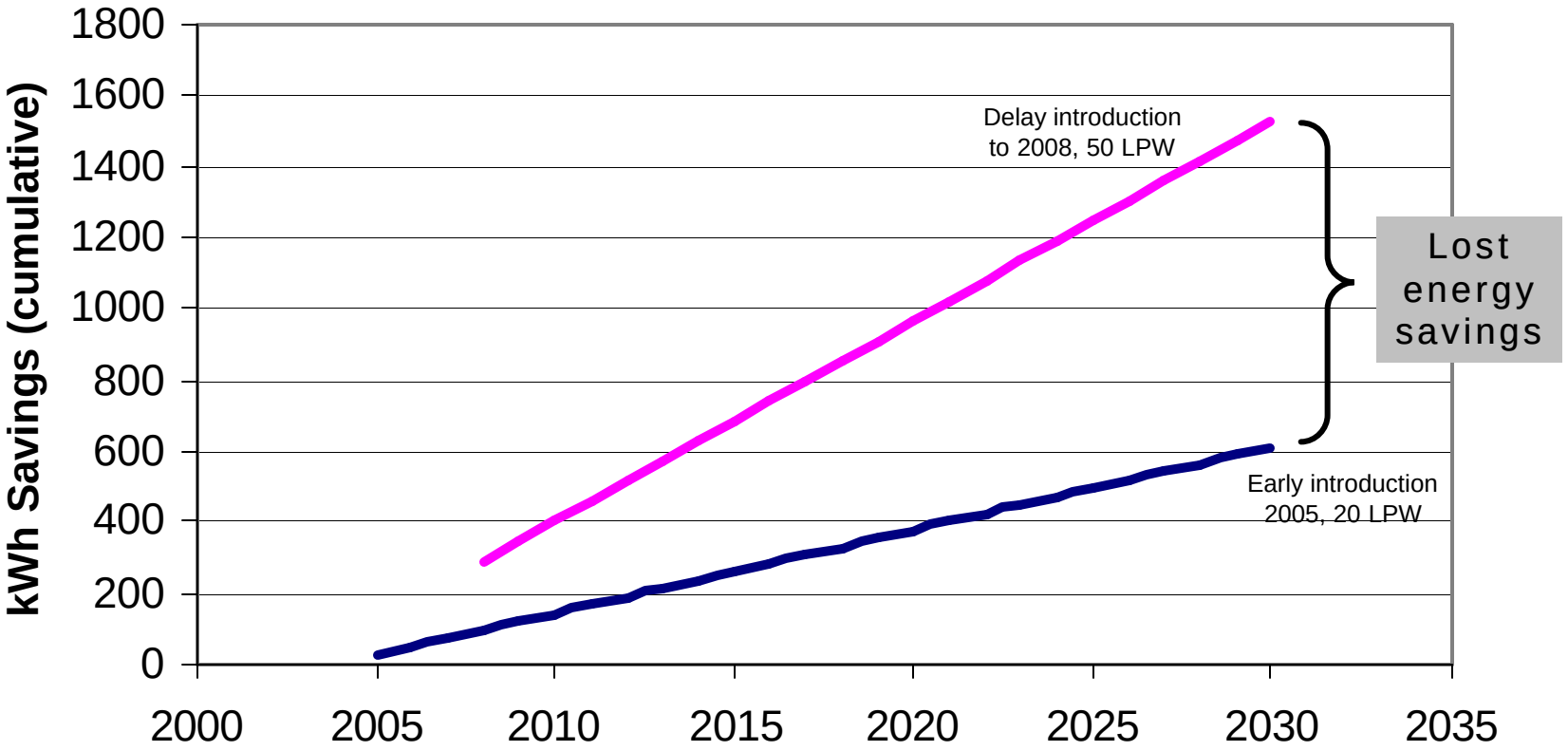
Initial White LED Applications

- Downlights, focused light applications
- Task lights, desk lights
- Undercabinet
- Display cases, including refrigerated
- Elevators – vibration resistance, long life
- Architectural – durability

Current Products on the Market

- MR16 replacements, desk lamps, outdoor
- Marketed as "energy-efficient"
- High prices
- Low light output
- Caveat emptor! Reality check-list:
  - ❑ Verify lumens per watt
  - ❑ Calculate $ per kilo-lumen
  - ❑ Assess need for special LED features (durability, etc.)
  - ❑ Check color quality
  - ❑ Get a sample

Importance of Strategic Timing Hypothetical LED Installation



Note: SSL replacing 14 LPW halogen sockets generating 1000 lumens for 3 hours per day. Replacement in 2005 with 20 lumen per watt white-light LED or delayed to 2008 with 50 lumen per watt. Efficacies held constant over time.